WILLIAM P. MINERVINI
48 LANTERN LANE
COLUMBUS, NEW JERSEY 08022
609-424-3275
billnjh2o@yahoo.com

March 28, 2019

Ariamalar Selvakumar, Ph.D., P.E.
Environmental Engineer
National Risk Management Research Laboratory
Office of Research and Development
U.S. Environmental Protection Agency
2890 Woodbridge Avenue
Edison, NJ 08837

Re: Suggested "Correction" to the article "Organism Detection in Permeable Pavement Parking Lot Infiltrates at the Edison Environmental Center, New Jersey." A. Selvakumar; T. P. O'Connor (2018) *Water Environ. Res.*, **90**, 21-29.

Dear Dr. Selvakumar:

Thank you for providing information about this article. I also thank the U.S. Environmental Protection Agency (USEPA) for responding to my Freedom of Information Act (FOIA) Requests EPA-HQ-2018-007139 and EPA-HQ-2019-001779 about this article. I am pleased that USEPA is conducting research in New Jersey about this subject.

My review of pertinent information, including USEPA files provided under FOIA, focused on indicator organism values for surface runoff at the two curb cuts (CC4 and CC5), and on associated weather data. Based on this review, I think you should consider submitting to the Water Environment Federation a proposed "Correction" to this article. This "Correction," which would be published in Water Environment Research, would:

- Provide additional information about sample collection, rainfall, and indicator organism values necessary for proper interpretation and use of results reported in the article.

- Substantially rewrite this article's "Effects of Weather" paragraphs, Figures 4 and 5 referenced therein, and the associated last sentence under "Conclusion."

Both items are discussed in detail below. Please let me know if you will submit a proposed "Correction" and the general nature of this "Correction," and then send me a copy of any 'Correction" you submit. Your decision will affect the timing and content of the "Comment"

(formerly "Discussion") of this article that I will submit for publication in Water Environment Research.

**Provide additional information**

1. The "Correction" should disclose that for CC4, no samples were taken at two storm events (one each in August and September 2015), and default indicator organism values of "<1" were used in this absence of sampling. The "Correction" should also explain why default CC4 values were used (why not for these two storm events instead rely solely on the CC5 values?), and why "<1" was selected.

   Furthermore, the "Correction" should disclose that for some CC4 and CC5 samples, the indicator organism value of ">24196" reported by the laboratory was changed to "24196" (and explain this change).

   The above disclosures would make it clear that for surface runoff, some of the "summary statistics" indicator organism values in the January 2018 article were probably below values corresponding to those actually present in some of the collected samples, and that to this extent this article provided conservatively low estimates of indicator organism concentrations reductions for permeable pavement infiltrates.

2. The "Correction" should disclose that for CC5 at one of the November 2015 storm events (and for some other locations at two other events), there was a grab sample (taken at an unknown time) rather than the "flow-weighted samples ... collected using programmable automatic samplers" described in the January 2018 article. This disclosure is necessary to correct an incomplete description of sampling methods, and should also discuss the concern that indicator organism concentrations based on a grab sample taken at an unknown time might be less representative of a storm event than those based on flow-weighted samples of that event. I assume that the following "Note" in the "Micro Sampling Times-2015-2017.xlsx" file is relevant:

   > "'Grab' Samples are samples taken from the overflow container where the sampler tubing is located. In that sense, it is still a composite of all the runoff that was received at the sampling location even though the volume was insufficient to trigger the autosampler."

3. The "Correction" should disclose that one of the December 2015 storm events would not have qualified as eligible under USEPA's NPDES permit application regulations for industrial stormwater discharges, because this storm event was not "at least 72 hours from the previously measurable (greater than 0.1 inch rainfall) storm event" (40 CFR 122.21(g)(7)(ii)). This circumstance does **not** mean the storm event in question should have been excluded from the January 2018 article. Storms in quick succession are a reality appropriately included in this kind of study. The suggested disclosure simply

alerts readers that indicator organism concentrations in this December 2015 storm event may have been substantially affected by washoff or other phenomena during the preceding storm event.

(Specifically, the first rain gauge tip of the "12/18/2015" storm event was on 12/17/15 at 10:38 AM (EST), which was less than 60 hours from the last rain gauge tip of the 6.8 mm "12/15/2015" storm event on 12/15/2015 at 1:48 AM (EST).)

4. The "Correction" should disclose that in nine storm events (for CC4) and four storm events (for CC5), more than 4.0 mm of rainfall occurred **before** the first flow-weighted CC4 or CC5 sample was taken, and that in four storm events (for CC4) and two storm events (for CC5), more than 8.0 mm of rainfall occurred **before** the first flow-weighted CC4 or CC5 sample was taken. (The maximum such rainfall was 9.7 and 11.9 mm for CC4 and CC5, respectively. See the rainfall table in item 2 below under "Effects of Weather." I chose 4.0 mm as a criterion because 4.0 mm exceeded the total rainfall of the "8/21/2015" storm event.)

   The "Correction" should then discuss the potential effects of this delay in sampling on measured indicator organism concentrations. Depending on the nature of the catchment and the sample collection system, the samples collected may not have directly included a considerable first part of the storm event, but may have indicator organism concentrations substantially affected by washoff or other phenomena in the first part of the storm event. If you believe such effects may have been substantial, then the "Correction" should explain why it was still appropriate for the January 2018 article to include the affected indicator organism concentrations.

   (The discrepancy between CC4 and CC5 in this regard also illustrates that in several storm events, the parts of the storm event sampled at CC4 and CC5 differed considerably, which hinders direct comparison of measured CC4 and CC5 indicator organism concentrations in these events.)

   Conversely, the "Correction" should also disclose that in one of the September 2015 storm events (specifically, the "9/11/2015" storm event), 8.9 mm of rainfall occurred **after** the last flow-weighted CC5 sample was taken (no CC4 sample was taken in this storm event). This early termination of sampling meant that the measured indicator organism concentrations did not account for almost the entire second half of this 19.7 mm storm event.

   In light of the preceding paragraphs in this item 4, the "Correction" should disclose the extent to which the measured flow-weighted CC4 and CC5 indicator organism concentrations were representative of entire storm events, and whether measuring CC4 and CC5 indicator organism concentrations representative of entire storm events was important to this study. It may be that in this study, such representative measurements were **not** necessary to evaluate the performance of permeable pavement in removing indicator organisms.

Concerning both the above discussion and the related "Effects of Weather" discussion below, following is a link to an "Edison stormwater study cloud" folder containing pertinent files:

https://1drv.ms/f/s!AqWLnhXjVjSJ2A_rWprxni7-Foe5

(I plan to include this link in the "Comment" I will submit for publication.)

This folder includes (i) a "USEPA Edison stormwater FOIA" subfolder, which contains USEPA files and letters responding to my FOIA requests; and (ii) a "WM Edison stormwater files" subfolder, which contains files I created in the course of reviewing the subject article. In regard to the above discussion as it pertains to rainfall amounts and the dates and times of rainfall and sample collection, see, in the latter subfolder, the "WM (date) rainfall and CC sampling.xlsx" file series (one file for each of the 16 storm events), the "WM rainfall, temperature, and CC sampling.xlsx" file (which summarizes information for the 16 storm events), and related comments in the "readme" file.

**Effects of weather**

The "Correction" should (i) disclose that there are multiple errors in this article's "Effects of Weather" paragraphs and Figures 4 and 5 referenced therein; and (ii) substantially revise these paragraphs and those Figures (and the associated last sentence under "Conclusion") due to these errors. In particular, the "Correction" should disclose the following specific errors:

1. The first sentence said that "Between July 2015 and February 2016, 16 sampling events were conducted, which equates to two events per month." This sentence is erroneous because there was only one sampling event in July and only one sampling event in January, but there were three sampling events in November and three sampling events in December.

   (This sentence would have been acceptable if it ended " ... **for an average of** two events per month.")

2. The second and third sentences said that "Rain depth ranged from 3.4 to 39.4 mm with the mean size of 18.6 mm and median size of 19.7 mm. Rain depth is normally distributed as shown in Figure 4."

   The first problem with these sentences (and Figure 4) is that the "39.4 mm" value, which pertained to the "9/30/2015" storm event, appears to be incorrect. For reasons set forth in the "readme" file in the "WM Edison stormwater files" subfolder, I view this storm event as having begun with the "9/29/2015 1:00:32 PM" tip (and having ended with the "9/30/2015 8:21:48 AM" tip), which corresponds to a total rainfall of 44.0 mm.

The larger problem is that when read together with the first sentence of this article's "Effects of Weather" paragraphs, the second sentence is erroneous because on its face it applies to the "16 sampling events" mentioned in the first sentence when, in fact, rain depth was not calculated for the last three of those events (as stated in the "Raw data-Temperature-Rainfall.xlsx" file). Thus, the rain depth statistics presented in the second sentence applied to only the first 13 sampling events (which is consistent with Figure 4, which erroneously graphed 13 rather than 16 "observations"). When all 16 sampling events are considered (and the "9/30/2015" storm event is assigned a total rainfall of 44.0 mm), the mean and median rain depths are 20.6 mm and 20.3 mm, respectively, and Figure 4 is revised to graph all 16 "observations."

A separate issue is that a storm event's total rainfall is **not** the primary rain depth statistic of interest for the kind of evaluation summarized in the January 2018 article. If, for example, one objective is to evaluate the effect of a storm event's rain depth on the flow-weighted indicator organism concentrations measured at a sampling location in that storm event, and if the final sample at that location was collected **before** that storm event's rainfall ended, then the "total" rain depth that should be considered is **not** the storm event's total rainfall but the "total" rainfall up until the time the final sample was collected. Subsequent rainfall in that storm event could not possibly have affected the indicator organism concentrations measured at that location in that storm event.

As an example, for CC5 the "9/11/2015" sampling event is of concern because although "Total Rainfall" was 19.7 mm (last rain gauge tip on 9/11/15 at 3:58 AM), only 10.8 mm of that rainfall occurred before the last CC5 sample was collected on 9/10/15 at 11:32 AM. (See the "WM 9-11-15 rainfall and CC sampling.xlsx" file.) This means that the CC5 results pertain to only about the first half of the "9/11/2015" sampling event, and that in regard to rainfall, any statistical analysis of the CC5 results should use the 10.8 mm of rainfall that occurred **before** the last CC5 sample was collected, **not** the "Total Rainfall" of 19.7 mm. In regard to CC5 results for the "9/11/2015" sampling event, rain that occurred **after** that event's last CC5 sample was collected is as irrelevant as if the rain fell in Australia.

Using rain gauge tip files and the dates and times when the first last CC4 and CC5 samples were collected, I calculated the following rainfall statistics for the 16 storm events ("Date" and "Total Rainfall (mm)" in the "Raw data-Temperature-Rainfall.xlsx" file are also shown for identification and comparison):

| "Date" | "Total Rainfall (mm)" | WM total rainfall (mm) | Rainfall (mm) before first CC4 sample | Rainfall (mm) before first CC5 sample | Rainfall (mm) before last CC4 sample | Rainfall (mm) before last CC5 sample |
|---|---|---|---|---|---|---|
| 7/30/2015 | 22.6 | 22.6 | 5.6 | 2.2 | 22.6 | 22.6 |
| 8/11/2015 | 21.3 | 21.3 | 9.5 | 1.4 | 21.3 | 21.3 |
| 8/21/2015 | 3.4 | 3.4 | No CC4 samples | 2.1 | No CC4 samples | 3.4 |
| 9/11/2015 | 19.7 | 19.7 | No CC4 samples | 2.8 | No CC4 samples | 10.8 |
| 9/30/2015 | 39.4 | 44.0 | 3.4 | 0.9 | 40.6 | 40.6 |
| 10/9/2015 | 10.8 | 10.8 | 3.5 | 0.8 | 10.0 | 9.7 |
| 10/29/2015 | 26.8 | 26.8 | 8.2 | 2.3 | 26.8 | 25.9 |
| 11/11/2015 | 11 | 11.0 | 4.0 | 1.5 | 9.9 | 8.1 |
| 11/20/2015 | 17.7 | 17.7 | 3.7 | grab sample* | 13.8 | grab sample* |
| 12/3/2015 | 15.1 | 15.1 | 8.6 | 8.2 | 14.9 | 14.9 |
| 12/15/2015 | 6.8 | 6.8 | 2.4 | 1.1 | 4.8 | 4.8 |
| 12/18/2015 | 26.4 | 26.4 | 2.6 | 1.4 | 26.3 | 26.3 |
| 12/30/2015 | 20.8 | 20.8 | 5.4 | 6.7 | 20.8 | 20.8 |
| 1/11/2016 | did not calculate | 38.3 | 6.2 | 2.3 | 37.5 | 37.3 |
| 2/4/2016 | did not calculate | 14.3 | 6.1 (approx.) | 7.8 (approx.) | 14.2 (approx.) | 14.3 (approx.) |
| 2/25/2016 | did not calculate | 30.0 | 9.7 | 11.9 | 19.4 | 19.4 |
| | | | | *at unknown time | | *at unknown time |

3. The second paragraph begins with this sentence: "Event temperatures ranged from –1.1 °C to 26.4 °C with a mean of 15 °C and median of 13.58 °C (Figure 5) ..." (The Figure 5 caption is "Mean temperature on event days.") This sentence and Figure 5, which are consistent with the "Raw data-Temperature-Rainfall.xlsx" file, are erroneous because the dates and times when these temperatures were measured were **not** the dates and times of the "event."

   With the exception of the "Date" of "9/11/2015" in that file, all "Average Temp" data in the "Raw data-Temperature-Rainfall.xlsx" file are identical to the average temperatures calculated using the "bldg_205_060916.xlsx" file for the calendar "Date" in the "Raw data-Temperature-Rainfall.xlsx" file. These calendar "Dates" do **not** correspond to the dates and times of storm event rainfall and sampling. For example, in five storm events, rainfall and runoff sampling (CC4 and CC5) ended the day **before** this file's "Date" value ("11/20/2015," "12/3/2015," "12/18/2015," "1/11/2016," "2/4/2016").

   Any serious discussion of "event temperature" requires definition of this term. My definition, developed for purposes of my suggested "Correction," applies to the objective of associating a storm event's temperature with the flow-weighted indicator organism concentrations at a particular sampling location in that storm event. In this context, I

define “event temperature” as the temperature in the period that begins when that event’s rainfall begins, and ends when the last sample in that event is collected at this location.

(Temperatures in the hours, days, or weeks **before** that event’s rainfall began may well have affected indicator organism concentrations measured in that event, but these temperatures are part of antecedent weather conditions, not “event temperature.” Temperatures occurring **after** that event’s final sample was collected at that location could not possibly have affected the indicator organism concentrations measured at that location in that storm event.)

Using the “bldg_205_060916.xlsx” file and the dates and times when rainfall began and when the last CC4 and CC5 samples were collected, I calculated the following CC4 and CC5 “event temperatures” for the 16 storm events (“Date” and “Average Temp” in the “Raw data-Temperature-Rainfall.xlsx” file are also shown for identification and comparison):

| “Date” | “Average Temp” | Event Temp CC4 | Event Temp CC5 |
|---|---|---|---|
| 7/30/2015 | 26.09 | 28.45 | 28.51 |
| 8/11/2015 | 22.71 | 22.99 | 22.98 |
| 8/21/2015 | 26.03 | No CC4 samples | 25.38 |
| 9/11/2015 | 26.35 | No CC4 samples | 24.22 |
| 9/30/2015 | 22.02 | 23.21 | 23.20 |
| 10/9/2015 | 18.63 | 17.95 | 17.97 |
| 10/29/2015 | 18.17 | 18.18 | 18.42 |
| 11/11/2015 | 12.97 | 12.92 | 13.29 |
| 11/20/2015 | 11.49 | 17.13 | grab sample* |
| 12/3/2015 | 8.05 | 9.10 | 9.09 |
| 12/15/2015 | 14.27 | 17.82 | 17.76 |
| 12/18/2015 | 7.48 | 13.53 | 13.52 |
| 12/30/2015 | 6.88 | 4.66 | 4.71 |
| 1/11/2016 | -1.07 | 11.36 | 11.16 |
| 2/4/2016 | 10.81 | 14.35 (approx.) | 14.36 (approx.) |
| 2/25/2016 | 9.15 | 8.52 | 8.45 |

*at unknown time

For CC4 and CC5, “event temperatures” (as I define them) ranged from 4.66 °C to 28.45 °C and from 4.71 °C to 28.51 °C, respectively.

For more information about “event temperature,” see, in the “WM Edison stormwater files” subfolder, the “Weather data for Date in USEPA file column heading.xlsx” file

(which was prepared to investigate and try to replicate how the "Average Temp" values in the USEPA "Raw data-Temperature-Rainfall.xlsx" file were calculated); the ""WM (date) event temperature.xlsx" file series (one file for each of the 16 storm events); the "WM rainfall, temperature, and CC sampling.xlsx" file (which summarizes information for the 16 storm events); and related comments in the "readme" file.

4. This article's "Effects of Weather" paragraphs also stated:

> "... Least-square log normal regression analysis of rain depth and indicator organism concentrations for all the surfaces had low coefficient of determination ($R^2 \leq 0.33$) ...
>
> "... Least-squares log normal regression analysis of temperature and indicator organism concentrations for all three surfaces had low coefficient of determinations ($R^2 \leq 0.20$)."

(The associated last sentence under "Conclusion" stated: "Rain depth and temperature did not appear to have any effect on either concentration of organisms or the performance of permeable pavement in this small data set; this observation should be confirmed with a larger data set.")

Two reasons why those regression analyses were invalid are the errors, identified in items 2 and 3 above, in rain depth and temperature data used in those analyses. Another major source of error in these analyses was their use of default indicator organism values of "<1" for CC4 at two storm events where no CC4 samples were taken. Although these default "<1" values might legitimately be used in providing conservatively low estimates of indicator organism concentrations reductions for permeable pavement infiltrates, these default "<1" values have no place in analyses of the effect of rain depth and temperature on concentration of organisms.

In addition, there is a need to discuss expressly the implications for regression analyses of changing (for some CC4 and CC5 samples) the indicator organism value of ">24196" reported by the laboratory to "24196."

Moreover, it would not have been appropriate to include in these regression analyses measured organism concentrations that were not adequately representative of the part of the storm event that occurred before the last relevant sample was taken. CC4 and CC5 measurements that might fall in this category include those from the November 2015 CC5 grab sample, and those taken in instances where more than 4.0 mm (or even 8.00 mm) of rainfall occurred before the first flow-weighted CC4 or CC5 sample was taken.

(For more information about the above concerns about organism concentrations, see the "Provide additional information" discussion above.)

Although the "Correction" should disclose that the regression analyses discussed in the article were erroneous, I do **not** think it is necessary for the "Correction" to provide new regression analyses in their place. I believe that the 16 storm event data set was too small for this purpose, especially in light of the absence of CC4 sampling at two of the four summer storm events; the unknown extent to which the ">24196" indicator organism values exceeded 24196; the concerns about whether some measured organism concentrations were adequately representative of the part of the storm event that occurred before the last relevant sample was taken; and the potential complicating effects of other weather conditions including (i) each event's rainfall intensity; and (ii) antecedent weather conditions including temperature, relative humidity, solar radiation, wind speed, time since previous rainfall, and depth and intensity of previous rainfall.

Please call or email me if you want to discuss any part of this letter or my "Edison stormwater study cloud" folder. I hope this letter and folder are useful not only in regard to the study that was the subject of the January 2018 article, but also in regard to ongoing and future research.

Sincerely,

/s/

William P. Minervini

48 Lantern Lane
Columbus, NJ 08022
609-424-3275
billnjh2o@yahoo.com